TECHNICAL STANDARDS FOR COLLECTION SYSTEM USERS

EVALUATION, MAINTENANCE, REHABILITATION AND REPLACEMENT

WET WEATHER PROGRAM

RENEWABLE WATER RESOURCES

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SECTION 1
INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

Renewable Water Resources (ReWa) embarked on an ambitious Wet Weather Program in 2018. This multi-year, multi-faceted effort was designed to provide adequate capacity in the ReWa's Sanitary Sewer System. The mission of the Wet Weather Program is to support the economic vitality of our Community, protecting our waterways by maintaining adequate capacity in the Sanitary Sewer System and eliminating sanitary sewer overflows (SSOs) at the selected level of service. We will achieve this mission through effective partnerships with our Collection System Users, private property owners and regulators.

The first facet of the Wet Weather Program is comprised of the requirements for the Capacity, Management, Operations and Maintenance (CMOM) Program which are contained in a separate document. The goal of the CMOM Program is to maintain the system such that the existing levels of infiltration and inflow (I/I) do not increase materially over time in the remainder of the system not within the Wet Weather Program.

These Technical Standards represent the next facet of the Wet Weather Program and provide detailed requirements for completion of the work described herein and were developed to ensure a consistent approach. These Standards include completion dates for various activities, which are described in terms of months from the Initiation Date.

1.2 PURPOSE

The purpose of these Technical Standards is to reduce the occurrence of SSOs in the ReWa and Collection System Users Sanitary Sewer Systems. These standards cover the analysis of existing data, collection of additional system data, preparation of rehabilitation plans, correction of serious defects requiring prompt attention, execution of the rehabilitation plans for the purpose of reduction in infiltration and inflow, development of a hydrologic model, and assessment of the hydrologic performance of the Sanitary Sewer Systems. The primary goal is to reduce I/I in specific targeted areas (Target I/I Reduction Areas). These Standards have been developed to be information-based so that resources are focused on the areas that require attention to mitigate SSOs. Where appropriate, these Standards include quality assurance/quality control procedures related to field data collection.

These Standards also address the relationship between the hydrologic performance of the Sanitary Sewer System and Rehabilitation Plans that will be developed and implemented by the Collection System Users under the Wet Weather Program.

1.3 SUMMARY OF THE TECHNICAL STANDARDS

The following is a brief overview of each section of these Technical Standards:

Section 1 – Introduction and Purpose

This section establishes the context for the Technical Standards.

Section 2 – Definition of Terms

This section provides definitions for the major terms used in the Standards.

Section 3 – Data Collection and Flow Monitoring

This section provides direction on SSO characterization, use of previously developed information, system inventory mapping and GIS data standards, flow monitoring procedures for both model calibration and Target I/I Reduction Area qualification, rainfall monitoring, sewer flow evaluation and flow evaluation reporting. Efforts related to flow monitoring and flow evaluation will be performed by ReWa in consultation with Collection System Users. Collection System Users shall be responsible for collection of data related to their sewer system to support the SSES Plan and Execution.

Section 4 – Hydrologic Performance Assessment

This section provides the standards for development and application of a hydrologic model that will be used to evaluate system performance under a variety of conditions. The model will be used to evaluate the pre and post rehabilitation peak flows for each Target I/I Reduction Area. Procedures and standards for model development, calibration and verification are included. These efforts will be performed by ReWa.

Section 5 – Condition Assessment of Sewer System

This section provides the guidelines for conducting detailed condition assessment, assessment standards for Target I/I Reduction Areas, and assessment reporting requirements. The information developed through these efforts will be used to develop the SSES Plans in accordance with the requirements in Section 6.

Section 6 – SSES Planning

This section establishes the requirements for preparing a prioritized plan for conducting the SSES work. This plan must be submitted to ReWa within 2 months of the effective date of initiation for their review and approval. The subsequent SSES Report that details the findings of these efforts must be submitted to ReWa for review and approval within 13 months of initiation.

Section 7 – Rehabilitation Planning

This section discusses using the results of the SSES work to develop specific plans for rehabilitation, including evaluation of the effectiveness of rehabilitation on inflow and infiltration reduction, cost estimates and schedules. Collection System Users will assess the approach and cost of achieving specific peak flow reduction outcomes. The Rehabilitation Plans will be submitted to ReWa for review and approval within 23 months of the Initiation Date. Rehabilitation shall be completed within 45 months of the Initiation Date. Record Drawings shall be submitted to ReWa within 49 months of the Initiation Date.

Section 8 – Post-Rehabilitation Evaluation of Target I/I Reduction Areas

This section discusses the final report incorporating elements from previous sections to assess the success of SSES and rehabilitation in addressing I/I Reduction Target Value. ReWa will perform these activities.

1.4 SUMMARY OF DELIVERABLES AND DUE DATES

The following table summarizes the key deliverables and proposed deadlines for submittal. Schedule extensions may be granted, at ReWa's sole discretion, if the Target I/I Reduction Area(s) are extensive. Submeter Basins, collections of Submeter Basins or ReWa Basins will go through this process in cycles until all Target I/I Reduction Areas are addressed.

Deliverable	Responsibility	Durations, months	Submittal Date, months from Initiation Date
Flow Evaluation Report	ReWa	NA	0
SSES Plan	Collection System User	2	2
SSES Plan Review and Approval	ReWa	1	3
SSES Results	Collection System User	10	13
Rehabilitation Plan	Collection System User	10	23
Rehabilitation Plan Review and Approval	ReWa	1	24
Rehabilitation Substantial Completion	Collection System User	21	45
Notify ReWa of Rehabilitation Substantial Completion	Collection System User	1	46
Submit Rehabilitation Record Drawings to ReWa	Collection System User	4	49

The above procedure follows a more traditional approach to the assessment and remediation of I/I from collector sewer systems. Alternative approaches may be considered for the remediation of sewer systems. Such alternative approaches shall be reviewed by ReWa prior to implementation of a work plan for the targeted sewer systems. Approval of alternative approaches is at ReWa's sole discretion.

Regardless of the approach used to achieve assessment of the collection system, the following activities should be planned for window of time each year to achieve the best data and results for the assessments:

- Flow Monitoring – October through March
- Flow Isolation, CCTV Inspection and Manhole Inspections – December through April
- Smoke Testing – June through October
- Dye Water Testing – as appropriate for the specific investigation need

1.5 REVISIONS TO THE REGIONAL TECHNICAL STANDARDS

Minor changes may be made in the Standards from time to time by ReWa.

SECTION 2
DEFINITION OF TERMS

The following words and terms that have been used in these Technical Standards shall have the meanings assigned to them below unless the context clearly indicates otherwise. Other commonly used terms are defined by reference to terms in the South Carolina Department of Health and Environmental Control (SCDHEC) R.61-67, Standards for Wastewater Facility Construction, unless otherwise specifically defined in these Technical Standards.

ADF

Average Daily Flow

Adequate Capacity (ReWa System)

Defines a Sanitary Sewer System which has demonstrated the ability to manage peak flows at a specific peak flow recurrence interval without causing or contributing to overflows from any component of the ReWa Sanitary Sewer System. The specific peak flow recurrence that will be used for the basis of identifying capacity enhancements shall be established by ReWa.

Demonstration of adequate capacity for wastewater pumping stations requires each pump station to be capable of transmitting specific peak flows with the largest pump out of service, without causing or contributing to overflows. Evaluation of adequate capacity shall consider the interrelationship between: i) each pump and the pump station immediately upstream from that pump station, ii) all pump stations through which flow from that pump station passes to the wastewater treatment plant receiving such flow, and iii) all pump stations discharging directly to the ReWa Sanitary Sewer System which receive flow from that pump station.

For ReWa gravity systems, adequate capacity shall mean that the system can convey the peak flow without exceeding a surcharge level of two (2) feet above the crown of a sewer pipe or two (2) feet below the rim of a manhole for manholes less than or equal to four (4) feet in depth.

ASCII

American Standard Code for Information Interchange

CCTV

Closed-circuit television

CMMS

Computerized maintenance and management system

CMOM

Capacity, Management, Operations, and Maintenance: A program of accepted industry practices to properly provide capacity in, manage, operate, and maintain a sanitary sewer system.

Collection System User

A satellite sewer system or municipality with a geographical area within the boundaries of ReWa's service area, having a separate governing Body with responsibilities for ownership and maintenance of sanitary sewers, but which is subject to regulation by ReWa as a User of the system.

A public entity that owns and operates a sanitary sewer collection system that collects wastewater and delivers it to ReWa for conveyance and treatment.

Collection System User Sanitary Sewer System

The wastewater collection and transmission system that is comprised of all portions of the individual Collection System Users collection system, including manholes, gravity sewers and force mains, lift stations, pump stations, and associated appurtenances. Private sewer laterals and clean outs from the property line or right-of-way line to the structure are not considered part of the Collection System Users' sanitary sewer system. The portion of the lateral from the connection to the sewer main to the property or right-of-way line (Public Lateral) should be part of the Collection System Users system[1].

Cost Effective I/I Reduction

As defined in 40 CFR 35.2005(b)(16): "The quantities of I/I which can be economically eliminated from a sewer system as determined in a cost-effectiveness analysis that compares the costs for correcting the I/I conditions to the total costs for transportation and treatment of the I/I, into its conveyance system."

Criticality

An expression of the condition of a sewer asset as it relates to consequences of failures within the associated sanitary sewer system. Criticality may consider factors such as environmental risk, public health risk (including potential impacts to drinking water sources from SSOs *(see **SSO**)*), economic risk (including potential impacts on new service connections due to sanitary sewer system capacity limitations), and operational risk.

Design Flow Rate

The flow rate specifically used as the basis of design for facilities within the regional sanitary sewer system.

[1] Under best management practices, the public lateral is considered the responsibility of the Collection System User since it is frequently a major source of I/I.

Diurnal Curve

A graphical or tabular representation of the variation of wastewater flow (excluding rainfall derived I/I contributions) over a typical, 24-hour cycle.

DWF

Dry Weather Flow

DWI

Dry weather infiltration

Dry Weather Overflow

Any sanitary sewer overflow for which the underlying cause is not attributable to precipitation related flows.

Event of Interest

Any wastewater flow event or specific rainfall event which is used to evaluate the performance of the sanitary sewer system.

Excessive Surcharge

The condition where gravity sewer flow depth surpasses two (2) feet above the crown of the sewer line that is conveying the flow OR where there is less than two (2) feet of sewer flow freeboard below the rim of a manhole for manholes less than or equal to four (4) feet in depth.

Flow Evaluation Report

A report prepared by ReWa in consulation with the applicable Collection System User that summarizes the results and outcomes of flow monitoring and hydrologic modeling within a Targeted I/I Reduction Area. The 5-year PHF for the submeter area shall be contrasted with the leakiness of the Targeted I/I Reduction Area and the ReWa WRRF leakiness threshold value.

GIS

Geographic Information System

Gravity Sewer Line

A pipe that receives, contains, and conveys wastewater not normally under pressure, but is intended to flow under the influence of gravity.

Ground Water

Sub-surface water that is stored in the voids between soil particles

Hydrograph

The graphical or tabular representation of flow volume over time which could depict a specific hydrologic condition.

Hydrologic Model

The hydrologic model is a representation of sanitary sewer flow in a set of connected tributary areas that characterize the hydrologic response of the overall meter basin. The Hydrologic Model should provide a Collection System User Meter Basin-level assessment of previously-defined areas that are high contributors of I/I, an evaluation of Flow Monitoring data in pre-rehabilitation conditions, an evaluation of I/I reduction in post-rehabilitation conditions, and a comparison to ReWa Meter Basin-wide I/I reduction goals

I/I

Infiltration and Inflow, which is a component of sewer flow contributed as a result of groundwater and precipitation that enters the sanitary sewer system *(see **Infiltration** and **Inflow**)*.

Illicit Connection or Discharge

An unauthorized connection or discharge to the sanitary sewer system, including but not limited to area drains, foundation drains, roof drains and sump pumps.

IMS

Information Management System, a formalized system to manage data.

Infiltration

Water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as, but not limited to, defective pipes, pipe joints, connections, foundation drains or manholes. Infiltration does not include, and is distinguished from, inflow.

Inflow

Water other than wastewater that enters a sewer system (including sewer service connections) from sources such as, but not limited to, roof leaders, basement drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cleanouts, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration.

Initiation Date

Refers to the date when ReWa delivers the Flow Evaluation Report to a given Collection System User. The Initiation Date will be specific to ReWa Meter Basins and Submeter Basins.

Interceptor Sewer

A sewer, typically without individual sewer customer connections, that is used to collect and carry flows from main and trunk sewers to a central point for treatment and discharge.

LACP

Lateral Assessment Certification Program developed by National Association of Sewer Service Companies *(see **NASSCO**).*

Level of Service

The peak sewer flow recurrence interval that the Sanitary Sewer System can convey without resulting in a capacity related SSO or excessive surcharging.

LTS

Long Term Simulation: An assessment of long-term rain and flow conditions on a sanitary sewer system used in the Hydrologic Modeling process *(see **Hydrologic Model**).*

MACP

Manhole Assessment Certification Program developed by the National Association of Sewer Service Companies *(see **NASSCO**).*

NASSCO

National Association of Sewer Service Companies

ODBC

Open Database Connectivity

O&M

Operation and Maintenance: Regarding daily operation and repairs not atypically seen within a sewer system and its components. In NASSCO *(see **NASSCO**)* standards, this often refers to a type of sewer asset defect.

Peak Flow

The maximum hourly wastewater flow that occurs at a specific location within the sanitary sewer system.

Peak Flow Recurrence

The statistical probability of achieving a certain peak sewer flow. Typically, these values are expressed in terms of return years, or return frequency. As an example, a 5-year peak flow recurrence represents the probable peak sewer flow that is expected to occur once every 5 years.

PACP

Pipeline Assessment Certification Program developed by the National Association of Sewer Service Companies *(see **NASSCO**).*

Private Service Connection/Lateral

That portion of the collection system used to convey wastewater from a building or buildings to the property line or right-of-way line prior to entering the sanitary sewer system owned by the Collection System User.

Prompt Repair

A prompt corrective action approach to sanitary sewer system rehabilitation that is warranted when certain asset conditions pose imminent risk of failure. This may include collapsed pipes, holes, extensive exposed rebar, large offset joints, and other such defects. These assets may be operable at the time of discovery but have a high likelihood of failure or potential for severe consequences.

Pumping Station

Facilities comprised of pumps which lift wastewater to a point physically higher than the wastewater elevation in the wet well, including all related electrical, mechanical, and structural systems necessary to the operation of that pumping station.

Ragging

Non-flushable wipes and other materials entering the sanitary sewer system that can cause buildup within the impeller/volute of a wastewater pump.

RDII

Rainfall-Derived Inflow and Infiltration. RDII is a parameter that can be measured, estimated, or synthetically generated through other means, such as flow monitoring data or hydraulic modeling.

Rehabilitation Plan

Documents to be developed individually by each Collection System User and reviewed and approved by ReWa that define specific measures to reduce Sanitary Sewer Overflows *(see **SSO**)*, address deficiencies identified in Target I/I Reduction Areas; identify improvements including control of I/I sources and improvements needed to ensure sustainability of the sanitary sewer infrastructure. Rehabilitation Plans will be specific to either ReWa Meter Basins, Submeter Basins or a collection of Submeter Basins within a single ReWa Meter Basin.

ReWa

Renewable Water Resources, Greenville, SC or any duly authorized personnel or contractor acting on its behalf.

ReWa Flow Meter

A temporary or permanent flow or pressure meter owned and operated by ReWa. ReWa Flow Meters are used to evaluate peak flows and to calibrate hydrologic and hydraulic models.

ReWa Meter Basin

Pre-defined ReWa Flow Meter Basins that are tributary to a ReWa flow meter and are comprised of numerous Collection System User Meter Basins *(see **Submeter Basin**).*

ReWa Sanitary Sewer System

The sanitary sewer system owned and operated by Renewable Water Resources (ReWa).

Replacement

Obtaining and installing equipment, accessories, or appurtenances which are necessary at the end of the design or useful life of the sanitary sewer system to maintain the capacity and performance for which such works were designed and constructed.

Rainfall Recurrence Interval

The statistical probability of achieving a rainfall of specific intensity, volume, and duration. Typically, these values are expressed in terms of return years. As an example, a rainfall with a 2-year recurrence interval has a probability of occurring once every two years.

Sanitary Sewer Overflow (SSO)

The unauthorized intentional or unintentional spill, release, or discharge of untreated wastewater from any portion of a sanitary sewer system before the headworks of a Water Resources Recovery Facility *(see **WRRF**)*. SSOs are reportable to DHEC per their requirements.

South Carolina Department of Health and Environmental Control (SCDHEC)

An agency of South Carolina overseen by the South Carolina Board of Health and Environmental Control. The Board's legal authority and composition may be found in S.C. Code of Laws, Section 44-1-20.

Sanitary Sewer Evaluation Survey (SSES)

A systematic examination of a sanitary sewer system or portion thereof to, at a minimum:

i) identify the condition of sewers, manholes, pump stations and associated appurtenances;
ii) identify I/I sources, locations, and associated extraneous flow rates;
iii) characterize the wastewater flow; and
iv) determine technically feasible, cost effective methods of rehabilitation.

Significant Rainfall Event

A rainfall event which results in an associated measurable increase of wastewater flow in the sanitary sewer system above dry weather flows *(see **DWF**)*. Significant rainfall events are defined solely for the purposes of flow monitoring data analysis.

SCADA

Supervisory Control and Data Acquisition: A computer system for gathering and analyzing real time data.

Submeter Basin

Pre-defined basin areas containing Collection System Users sewers within ReWa Meter Basins *(see **ReWa Meter Basin**)*. A subarea within a ReWa Meter Basin.

Target I/I Reduction Area

A defined portion of the Sanitary Sewer System that is tributary to a ReWa flow meter and where ReWa has established a cost-effective level of I/I removal. Target I/I Reduction Areas are comprised of Collection System Users Sanitary Sewer Systems. The area is one in which historical data and/or flow monitoring data collected indicate high levels of RDII, unresolved SSOs, or other characteristics described in Section 5.1 that warrant investigation. Target I/I Reduction Areas will be subject to investigation to identify infrastructure deficiencies and define rehabilitation efforts for peak flow reduction to achieve the Target Value.

Target Value

The quantity of Inflow and Infiltration *(see **I/I**)* Reduction established by ReWa in each of the Target I/I Reduction Areas *(see **Target I/I Reduction Area**)* expressed as a percentage of the peak hour flow and in units of gallons per day, peak hour flow.

Unresolved SSO

Any Sanitary Sewer Overflow *(see **SSO**)* for which the underlying cause has not been resolved so as to prevent future reoccurrences at that location from that cause.

Useful Life

The length of time or period during which infrastructure assets operate. Useful life is not synonymous with "design life" which is defined as the period over which infrastructure assets are planned to be used and designed to be operated.

Water Consumption

The volume of potable water consumed by residential, commercial, and industrial users as measured by potable water meters.

Water Environment Federation (WEF)

A not-for-profit organization providing education and training for water quality professionals.

Water Resources Recovery Facility (WRRF)

A facility where wastewater is treated prior to discharge in accordance with an NPDES permit.

WRRF Threshold Leakiness

The I/I density, in gallons per acre-day, that represents the Cost Effective I/I Reduction level within the service area of one of ReWa's WRRFs as determined by ReWa's cost effective analysis.

SECTION 3
DATA COLLECTION AND FLOW MONITORING

Note: Sections 3.1 through 3.8 are the responsibility of the Collection System User whereas ReWa will perform the work in Sections 3.9 through 3.20

3.1 REVIEW OF EXISTING INFORMATION

Development of the SSES program components requires sound system knowledge. Existing sewer system information shall be compiled and evaluated to establish the basis for identifying additional data needs as determined by the Collection System User.

Information sources shall include the following, as available and appropriate for the specific system:

- Sewer system maps
- Engineering and design studies, including hydraulic analyses
- SSES studies
- Pump Station design capacity evaluations
- Any existing system condition/inspection data
- Maintenance staff interviews
- Operation and maintenance records
- Treatment plant flow and operation records
- Pumping station flow records and SCADA data
- Sanitary Sewer Overflow (SSO) reports
- Customer complaint records
- Existing Asset Condition Data (e.g., CCTV records)
- Root maintenance history

A suitable data acquisition plan shall be developed and implemented to address data gaps and information needs. ReWa may request this information on an as needed basis in support of their review of the SSES Plan.

3.2 SANITARY SEWER OVERFLOW CHARACTERIZATION

The cause, location, estimated quantity and frequency of all sanitary sewer overflows (SSOs) that have occurred during the past five (5) years shall be analyzed to determine where there may be unresolved maintenance, structural, and capacity issues. SSOs may be classified according to the following causes (or a similar classification system):

- Maintenance
  - Grease
  - Roots
  - Debris (including sediment accumulation)
- Infrastructure

    - Pipe Failure/Defects
    - Equipment Failure

- Capacity
    - I/I
    - Unanticipated Wastewater Flows
    - Pressure Problems
    - Reverse Grade
    - Hydraulic Bottlenecks
    - Inadequately Sized Infrastructure

- Damage by Others
    - Vandalism
    - Contractor Damage
    - Illegal Discharges

- Power Outages
    - Response Times

SSO evaluation shall be conducted to identify chronic problems and develop appropriate mitigation actions for each SSO. The SSO locations shall be identified on a sanitary sewer system map, preferably in GIS, and coded by cause. This action will facilitate the SSO analysis.

3.3 ENGINEERING AND OPERATIONS

Sewer system engineering and operational information that is useful in SSES Planning includes:

- Mapping of the project area showing sanitary sewer systems, streets and roads, contours and spot elevations, and storm sewers and appurtenances
- Design drawings, pump curves, design reports, and operating data (pump run time logs)
- SCADA (or equivalent) information to include system pressure, metered flow, pump run times, wet well levels, and alarm and event data
- Information on work order history and maintenance records for sewer facilities
- Historical water consumption data
- Rainfall gauge data
- Groundwater monitoring level data

These data shall be used, where applicable and available, to identify problem areas within the sanitary sewer system that result from connectivity issues, design limitations, or maintenance issues. These data may also be used to help define the activities needed to further investigate and/or collect additional information about the system.

3.4 OTHER PERFORMANCE DOCUMENTATION

Known ongoing operational and/or maintenance problems shall be reviewed prior to the initiation of the field investigations. This information will be obtained through consultation with the Collection System User's staff. The list below is representative of the types of issues that shall be investigated:

1. Based on the experience of the staff, where are the significant problem areas in the sanitary sewer system?
2. Have there been any significant recent changes in the patterns or type of sewer problems (overflows, stoppages, collapses, etc.) from those identified in prior investigations or other prior studies?
3. Have there been repairs conducted that were identified in prior investigations?
4. Which sewer lines within the study area are currently on a routine cleaning program, and do they correlate with past problem areas?
5. Can reported problems such as grit, grease, roots, or inflow be substantiated through a preliminary inspection of critical manholes or sewer segments?
6. Are there any easement or right-of-way issues affecting the access, such as backyard locations?
7. What are the local issues regarding traffic control, site accessibility, and maintenance activities?
8. Is the force main manifolded with another pumping station? If so, are there discharge pressure issues?
9. Under what conditions and how long does the pumping station require all pumps to operate?
10. Does Excessive Surcharging (see Section 2) occur in the system? If so, where and under what conditions does this surcharging occur?
11. Have there been construction activities by others within the sanitary sewer system service area where rehabilitation techniques have been used that may have damaged pipes or reduced the capacity of pipes and/or pump station?

3.5 SYSTEM INVENTORY

An inventory of the sewer system's components shall be prepared so that those components can be consistently referenced during the SSES and subsequent analyses. The inventory shall include:

- Gravity Mains
- Laterals, if applicable
- Manholes
- Pump stations
- Force mains
- Appurtenances (e.g., valves, clean outs, siphons)
- WRRF

3.6 MAPPING STANDARDS

The mapping shall be developed using the South Carolina State Plane Coordinate System with a known vertical control that can be easily transferred to other standard vertical datum.

3.7 GIS DATA STANDARDS

To compile a GIS dataset for the Collection System User's sanitary sewer system, the following major datasets are needed:

- GIS base mapping
- Available supplemental GIS base mapping data
- Existing sanitary sewer system GIS data
- Existing electronic format of sanitary sewer system maps GIS data is not available

Sewer system GIS data shall include gravity pipes, manholes, pump stations, force mains, valves, and other pertinent facilities. The GIS data shall be transferable to ReWa. The GIS data formatting shall be agreed upon between the Collection System User and ReWa prior to data collection activities. ReWa shall provide each Collection System User with a data-mapping scheme for the transfer of GIS data. The Collection System User shall provide the necessary data to ReWa in the agreed upon format. All GIS data shall have metadata associated with each data set.

3.8 EXISTING PHYSICAL ATTRIBUTION

Physical attribution is needed to describe the various facilities within the system. Naming conventions may be adjusted through collaboration with ReWa. The following attributions shall be included:

Pipe:

- Feature ID
- Upstream and downstream manholes or junctions
- Pipe size (inside diameter)
- Length
- Gravity line invert elevations (upstream and downstream)
- Pipe material
- Approximate pipe installation date / age
- Pipe condition (NASSCO standards)
- Pipe type (e.g., force main or gravity sewer)
- Prior rehabilitation

Manholes:

- Manhole ID
- Diameter

- Spatial coordinates
- Pipe invert elevations
- Rim elevation
- Ground elevation
- Sealed or unsealed lid
- Sump elevation
- Approximate manhole installation date / age
- Prior rehabilitation

Pumping Stations:

- Pump station ID
- Wet-well physical attributes (i.e., dimensions)
- Pumping capacity (i.e., pump performance curves, draw down test results)
- Number of pumps
- Type of drive (i.e., variable speed, dual speed, or constant speed)
- Control logic (i.e., wet well elevations at which each pump turns on, reaches full speed, and turns off)
- Piping details
- Flow equalization/storage attributes and control strategy
- Special equipment (e.g., pressure regulating valves)
- Flood plain location
- Approximate pump/pump station installation date / age

Where the data is not available, assumptions shall be made to complete the data set based on best management practices. Such assumptions shall be clearly stated.

Delivery of asset data shall be in GIS format, where available. ReWa is developing documentation standards

3.9 FLOW MONITORING PROGRAM

ReWa shall conduct flow monitoring in the Target I/I Reduction Areas. Flow monitoring shall be conducted to characterize the flow regime in the sanitary sewer system. ReWa has identified Target I/I Reduction Areas corresponding to ReWa flow meter basins. ReWa shall perform submetering within these Target I/I Reduction Areas to further characterize areas with higher I/I densities and flows. The objectives of the flow-monitoring program are as follows:

- Collect representative dry and wet weather flow data for the sewer basin(s)
- Identify conditions that cause sewer surcharging
- Quantify dry weather infiltration
- Estimate rainfall derived inflow and infiltration (RDII) volumes
- Correlate RDII with rainfall volumes and intensities
- Determine and assist in prioritizing Target I/I Reduction Areas

- Quantify potential dry-weather inflow (e.g., manholes located in low-lying areas which may be inundated in dry weather by stream flow)
- Determine whether areas within a Target I/I Reduction Area or Submeter Basinare above or below the target leakiness threshold for the applicable WRRF service area.

The scope of the flow-monitoring program shall be developed to ensure data collection is adequate to meet the program objectives. Flow data that has been collected within five (5) years prior to the Initiation Date which meets the requirements established within these Technical Standards, may be used. Before defining the scope, ReWa shall determine:

- The adequacy of existing data from prior studies (e.g., study areas in which no significant changes have occurred since the flow monitoring took place)
- Extent that pump station data can be used to quantify flows
- Equipment types and availability
- Where flow monitoring is needed
- Types of flow to be monitored
- Cost to collect and evaluate the data
- The seasonal variations of flow within the sanitary sewer system, if significant

3.10 METER SITE SELECTION AND BASIN DELINEATION

Selection of meter location sites is critical to defining sewer basins. Flow meter sites shall be selected to maximize the flow for the area of interest to be characterized. This may require multiple meters for areas with parallel sewers or complex connectivity. Meter sites shall be compatible with the minimum requirement of the flow monitoring equipment manufacturer relative to physical site constraints.

Sewer basin delineation can be accomplished through use of sewer mapping. It is important that the meter locations are strategically selected to provide an appropriate delineation of sanitary sewer system basins.

Sewer basins shall be correlated to ReWa meter basins. Basins shall be large enough so that open channel flow meters can accurately capture velocity and level data. Minimum sewered area for basins is approximately 50 acres and maximum desired area is 500 acres. ReWa shall review meter sites and associated basin delineation with the applicable Collection System Users prior to the deployment of flow meters.

3.11 ACCEPTABLE FLOW MEASURES AND RECORDING

Equipment may consist of one or more of the following: open channel flow monitors, SCADA data (pump run times, discharge pressure and volumetric data) capable of computing flow or monitoring flow in force mains. Flow monitoring equipment shall include a data logger, communication device and sensing unit. Where pressure pipe flow monitoring is to be performed for pump discharge flow measurements, magnetic flow meters or ultrasonic meters should be used. Where flow is measured in force mains, pressure shall also be measured. All gravity sewer metering equipment shall be capable of recording in both low flow and surcharged conditions for wet weather monitoring. ReWa shall utilize engineering judgment in the selection of flow monitoring methods and the application of the resulting data.

Smart manholes covers capable of sensing level may be used to supplement flow meters. These devices can be used to identify areas of surcharging.

Strengths and limitations for each flow monitoring method shall be evaluated considering characteristics of the flow to be measured and the location to be monitored. Note that the pump station volumetric method of determining flow rate is not reliable for conditions where wet well levels surcharge into the incoming sewer lines, or where variable frequency drive units are in place, unless other metering is used to account for flows being discharged from or entering the pump station. Pump curves and system curves shall be verified when using this methodology to estimate flow rates. Caution should be exercised in application of this methodology. It is most appropriate for pump or lift stations with constant speed pumps that discharge to gravity sewers.

3.12 DURATION OF FLOW MONITORING

For the purposes of model calibration and identifying areas for SSES activities, temporary flow measurement shall be conducted. The flow data shall capture a representative sample of dry weather flows as well as several storm events of varying magnitudes. Temporary flow monitoring shall be conducted for a duration that satisfies the following minimum criteria:

Flow Monitoring for Hydrologic Model Calibration and Target I/I Reduction Area Subdivision:

- Flow monitoring period shall be of sufficient length to capture typical diurnal variations in dry-weather flow, including weekends and weekdays.
- Flow monitoring that captures three individual wet-weather events each of which provide a system wet weather flow response, including a rainfall event with at least a one year rainfall recurrence interval, or at least six months if the one year recurrence interval is not achieved provided that there is at least one event where the total 24 hour rainfall exceeds 1.5 inches. These events shall capture system response under a variety of antecedent rainfall and groundwater conditions.
- Flow monitoring shall continue for sufficient time between rain events to allow for the flow to return to dry weather conditions.
- Flow monitoring shall be conducted during a period that provides the highest probability of wet conditions.
- If flow monitoring produces very low flow readings and wet weather response is weak after review by ReWa, monitoring for an area may be terminated prior to the collection of sufficient data.

Flow monitoring for Target I/I Reduction Area Identification shall be conducted for at least 70% of the Collection System User's sewered area within Target I/I Reduction Areas unless it can be demonstrated that the remaining areas have too many small connections to the ReWa system to allow for meaningful flow data collection or that a full SSES investigation will be conducted in these areas.

ReWa and the applicable Collection System User may, by mutual agreement, decide not to collect any additional flow data in a Target I/I Reduction Area if the Collection System User plans to collect comprehensive SSES information in that Area.

Flow monitoring data shall be reviewed for conformance with the criteria for hydrologic model calibration and verification, as well as Target I/I Reduction Area qualification. If the review of the monitoring data indicates the criteria has been satisfied temporary metering can be discontinued. Otherwise flow monitoring shall continue until adequate data is obtained.

3.13 DATA ACCURACY SPECIFICATIONS

Flow monitoring accuracies will be based on typical accuracies for the type of equipment used. Flow meters shall monitor flow between sample periods and provide maximum and minimum values at 15-minute intervals. Additionally, flow meters shall be capable of collecting and reporting data at five (5) minute intervals when the percent change in flow is greater than ten percent (10%) in any fifteen (15) minute interval.

Prior to installation of any meter and/or gauge, the device shall be calibrated according to manufacturer's recommendations. The calibration of open channel flow meters will be checked monthly after installation using supplemental velocity and/or level measurement devices, where the use of such devices is practical. Calibration records shall be included in the flow evaluation report to demonstrate that the equipment was properly calibrated. Any recalibration required during the monitoring period shall be noted and also included in the report. The meters should be maintained in a manner that shall provide for a minimum:

- Seventy-five percent (75%) data reliability for each individual meter during a monthly monitoring period
- Ninety percent (90%) for all meter data should be maintained during qualifying rain events

Data reliability means the percentage of flow data that has been collected and is not obviously incorrect (i.e., flat lines, capped peaks due to overflows, or data that has drifted from known calibration levels).

Rainfall, flow, and pressure monitoring shall be carried out in accordance with current standard practices and shall generally be in conformance with widely used industry guidance such as WEF's MOP FD-6 "*Existing Sewer Evaluation and Rehabilitation,*" and NASSCO guidance.

3.14 RAINFALL MONITORING

Rainfall monitoring shall be done to obtain the data needed to compare wet weather sewer flow to rainfall volume, duration, and intensity. The relationship between peak sewer flow and rainfall shall be used during the evaluation of the sewer system's performance and the prediction of rainfall derived inflow/infiltration (RDII). Rainfall gauges shall be of the continuous recording type, and store data in 15-minute increments. Rain gauges shall be located within 2 miles of the ReWa Meter Basin centroid. The placement of rain gauges shall be coordinated between ReWa and the Collection System Users. That density should provide reasonable coverage and representation of variations in rainfall intensity, duration, and accumulation throughout the sewer system. Rainfall gauges shall be capable of recording rainfall at 0.01-inch intervals or less.

Rain data can be supplemented by data from gauges maintained by United States Geologic Survey (USGS) and/or the National Oceanic and Atmospheric Administration (NOAA). Rain gauge data may also be supplemented by radar rainfall records derived from radar information that is calibrated with rain gauges maintained by the USGS, NOAA, and ReWa.

3.15 FLOW MONITORING IMPLEMENTATION

Sewer flow monitoring information shall be used to characterize the performance of the sanitary sewer system during dry and wet weather flow conditions and to characterize the flow conditions that cause surcharging and/or overflows within the system.

3.16 DATA COLLECTION

Sewer flow, force main pressure, and rainfall information shall be collected (downloaded) at periodic intervals for the duration of the monitoring period. In cases where area-velocity meters are used to monitor flow in gravity sewers, a site visit after a major storm event is highly recommended to confirm meter conditions and to download the meter data.

Collection and transmission of data for flow monitoring and rainfall gauging sites is required to be in an electronic format.

3.17 DATA SUMMARIES

Flow data summaries to be included in the Flow Evaluation Report shall present the flow data and observed flow conditions supported by graphical and tabular presentations of flow, wet well level, velocity, and pressure in the context of the qualifying rain events. Each summary shall include the following information:

- Graphical representation of data
- A graphical time-series plot (hydrograph) of flow rate vs. time data, as well as associated recorded rainfall data, shall be presented for each specific flow monitoring method below

Additional data summaries for various flow-monitoring methods are suggested below:

- Open Channel Flow Meters: Graphs (scatter graph) of flow depth versus velocity
- Force Main Flow Meters: Graphs of flow rate and associated system pressure versus time
- Volumetric Flow Calculation: Graphs of wet well levels and calculated flow rate
- Alternate methodologies for flow measurement and hydrograph development: Verified pump and system curves
- Tabular data

A tabulation of daily average, maximum, minimum, and peak hour flow rate recorded during the flow monitoring period shall be presented. The following data shall be tabulated for each specific flow metering method for representative dry weather conditions and for the specific rainfall events of interest used to calibrate the hydrologic model:

- Open Channel Flow Meters:
  - Time
  - Flow depth
  - Velocity
  - Flow rate
- Force Main Flow Meters:
  - Time
  - Flow rate
  - Pressure
  - Pump run status
- Volumetric Flow Calculation:
  - Time
  - Wet well levels
  - Pump run status
  - Pump run times
  - Flow rate calculation
  - Pressures, where available
- Installation report:
  - A summary of the installation details associated with each meter location is required, including, but not limited to:
    - Flow Meter Identifier
    - Manhole Identifier
    - Meter Serial Number
    - Location (Address and Coordinate Points)
    - Pipe Material
    - Pipe Diameter
    - Manhole Type

- Manhole Depth
- Upstream Manhole Identifier
- Traffic Concerns
- Site and Flow Conditions (e.g. debris accumulation, hydraulic suitability)
- Meter Setup and Configuration
- Manhole flow diagram showing inflows and outflows
- Site map
- Photos of the installation location and the sensor in the pipe

A hydrologic model shall be developed and calibrated in accordance with the requirements of Section 6 of these Technical Standards by ReWa. Long term simulation (LTS) in accordance with the requirements of Section 6.6 shall be performed by ReWa. Results of the LTS shall be presented in a Log Pearson Type III plot. I/I density in gallons per acre-day (gpad) shall be calculated for the metered area using the sewered area tributary to the meter. The subarea I/I density shall be compared with the WWRF leakiness threshold value and the leakiness of the ReWa meter basin. These results shall be included in the Flow Evaluation Report and will inform the Collection System User's SSES Plan for that subarea.

3.18 DATA STORAGE FORMAT AND WAREHOUSING

The metered data shall be stored in an open data format that can easily be accessed in an ODBC (Open data base connectivity) compliant format.

Data for each meter should be uniquely identified and shall be distinguishable from the data from other meters. Further, the data shall be labeled and stored in a manner that will allow ease of site location identification and determination of the dates on which the data were collected.

ReWa will make this data available for viewing by the Collection System Users.

3.19 Instrument Maintenance

Instrument operation shall be checked monthly. Problems with the instrument shall be corrected as soon as possible to sustain data collection at the highest level.

3.20 Flow Evaluation Report

The Flow Evaluation Report will be prepared in consultation with the applicable Collection System User. ReWa will meet with the applicable Collection System User at the following milestones during the preparation:

- Prior to flow meter deployment to verify subbasin characteristics
- After data collection and analysis
- To present the Flow Evaluation Report

The Flow Evaluation Report shall contain the following information:

- TITLE PAGE
    - Project Title
    - Collection System User Contact Information
    - Basin, Sub Basin ID
- EXECUTIVE SUMMARY
- INTRODUCTION
- FLOW AND RAINFALL MONITORING METHODOLOGY & APPROACH
    - Use of Existing Data
    - Monitoring Site Selection
    - Monitoring Equipment Used
    - Data Collection Activities
    - QA/QC Procedures
- MONITORED FLOW CHARACTERIZATION AND ASSESSMENT
    - Data Analysis Overview
    -
    - Dry Weather Flow Analysis
    - Dry Weather Infiltration Analysis
    - RDII and Rainfall Analysis
    - Hydrologic Model Calibration
    - Long-Term Simulation (LTS) Model
- FINDINGS AND CONCLUSIONS
    - Discussions of Findings
    - Comparison of Observed I/I Density to ReWa Meter Basin and/or Submeter Basin I/I Density
    - Areas Meeting the Target I/I Reduction Area Criteria
    - Success of Rehabilitation Efforts in achieving Target I/I Reduction Area Value
- APPENDICES
    - Field Data
    - System Monitoring Location Maps

SECTION 4
HYDROLOGIC PERFORMANCE ASSESSMENT

4.1 Use of Hydrologic Models

Calibrated hydrologic model(s) of the Sanitary Sewer System shall be developed and used by ReWa to support the following objectives:

- Collection System User Meter Basin-level assessment of previously defined areas that are high contributors of I/I
- Evaluation of Flow Monitoring data in pre-rehabilitation conditions
- Evaluation of I/I reduction in post-rehabilitation conditions
- Comparison to ReWa Meter Basin-wide I/I reduction goals

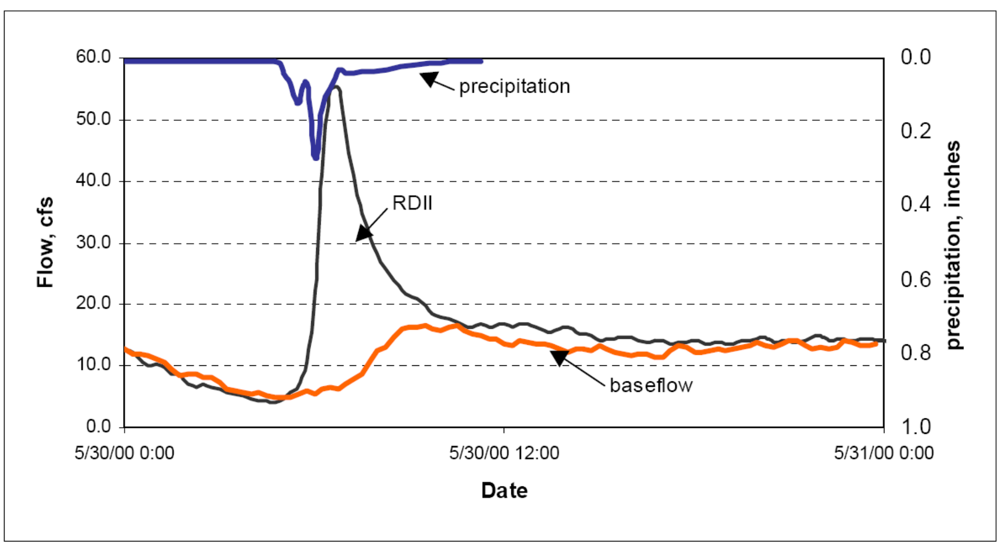
4.2 Hydrologic Flow Assessment Background

The hydrologic model includes a set of connected tributary areas that characterize the hydrologic response of the overall basin. To understand what is going on in the sewer, flow meters can be installed at strategic locations to monitor depth, velocity, and flow. A great deal of insight can be gained by studying the flow meter data, but it is necessarily limited to a few spots in the system where the meters are located.

4.2.1 Components of Flow

Sewer flow consists of base DWF and rainfall derived I/I (RDII), as shown on Figure 4-1.

Figure 4-1. Components of Sewer Flow



4.2.1.1 DRY WEATHER FLOW (DWF)

DWF is constant flow which includes flows generated from residential, commercial, and industrial users. It also includes chronic dry-weather infiltration that is independent of rainfall. These flows shall be predicted based on population and per capita unit flow rates or based upon water consumption for commercial facilities or from wastewater discharge records from industrial facilities. DWI results from defects in the sanitary sewer system that are located below the water table that allow groundwater to enter the system. Average daily flow (ADF) values and diurnal patterns should be developed from the observed dry days at each flow meter location.

DWI would normally be accounted for by applying a constant DWI rate above the population based domestic sewage flow.

4.2.1.2 RAINFALL DERIVED INFLOW AND INFILTRATION (RDII)

RDII is the component of total wastewater flow resulting from rainwater entering the sewer system.

RDII is generally a substantial portion of the total sewer flow that occurs during wet weather events. In many cases, particularly in older sewers, RDII may be the largest component of wet weather flow. RDII varies with rainfall volume, rainfall intensity, antecedent moisture conditions, the condition of the collection system, and other factors. The constituents of RDII are inflow and infiltration.

4.2.1.3 SEPARATION OF DWF AND RDII

Total observed sewer flow shall be separated into DWF and RDII using the following procedure:

- Separate periods of dry and wet weather flow with respect to rainfall data
- Establish a typical 24-hour, dry weather sewer hydrograph
- RDII is extracted by subtracting the DWF hydrograph from the wet weather hydrograph for the event or events of interest

4.2.1.4 DWF ESTIMATES AND PROJECTIONS

Dry Weather Flows are estimated by applying unit flow rates to population data plus the addition of DWI.

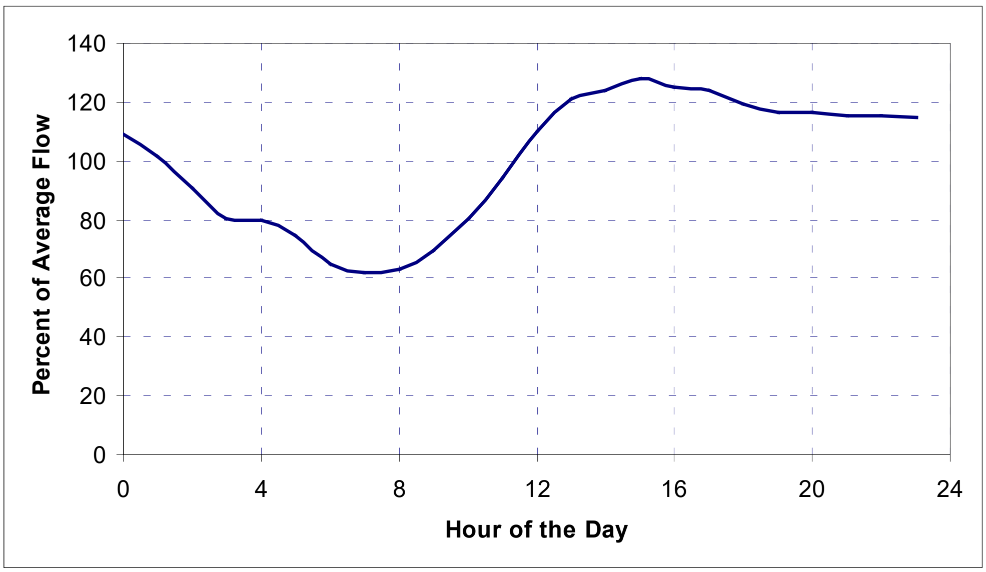
Variability exists in all unit flow rates. Industrial unit flow rates tend to have the greatest variation due to the volume of process water used in production, production schedule, and production methods. In the absence of industry specific information, consideration should be given to using flow monitoring to determine a suitable value based on engineering judgment.

It may be necessary during model calibration and testing to adjust the unit flow rates to match the observed DWF.

4.2.1.5 VARIATIONS IN DRY WEATHER FLOW

Dry Weather Flow may vary daily, weekly, or seasonally. Daily variations in DWF shall be accounted for using diurnal curves. Diurnal curves shall be normalized based on average daily DWF to produce a unit diurnal curve. Unit diurnal curves shall be used to develop DWF hydrographs based on observed or predicted average daily flow. Figure 4-2 illustrates a typical diurnal curve, normalized by average daily flow.

Figure 4-2. Example Diurnal Curve



Unit diurnal curves shall be created by:

- Developing a typical dry weather hydrograph from a representative period
- Dividing the DWF hydrograph by the average daily dry weather flow, for the representative period

This unit hydrograph can be multiplied by average daily flows for various population conditions. This provides a method to generate future hydrographs based on population projections. Ideally, several days of DWF data should be used for the development of the unit hydrograph, including weekdays and weekends.

If seasonal or weekly variations exist in the area being modeled, specific unit diurnal curves should be developed for these periods using the same technique. Note that seasonal variations may also require an adjustment to the population data, such as during peak tourism, to accurately characterize seasonal variations in DWF.

It is understood that flow monitoring data will not be collected specifically for each individual sewer basin. For sewer basins that have not been individually monitored, diurnal curves shall be estimated based on diurnal curves from comparable basins with similar basin characteristics, particularly land use and area, using engineering judgment.

4.2.1.6 RAINFALL-DERIVED INFLOW AND INFILTRATION GENERATION

RDII generation techniques shall be limited to those which estimate the stormwater generated hydrograph, as described in this section. The modeler may use engineering judgment to select the RDII generation technique.

Note that some of these methods may not be available in all commercially available hydraulic modeling software. To apply a method not included in a given software package, sewer hydrographs will need to be developed outside of the software. Note that no method is more accurate or precise than the data which are used to develop the RDII estimate.

It is understood that flow monitoring data will not be collected specifically for each individual sewer basin. For sewer basins that have not been individually monitored, RDII shall be predicted based on comparable results from monitored basins with similar basin characteristics using engineering judgment. The variables used to predict RDII shall be scaled as appropriate in non-monitored basins to develop proportional RDII as observed in the monitored basins of similar basin characteristics.

The modeler shall use engineering judgment when projecting RDII for future conditions. This assessment shall be made based on pipe age, condition, current versus future extent of sanitary sewer system, and experience.

RDII flow generated from models calibrated using a relatively short history of rainfall and flow records (i.e., less than the requirements in Section 3) should be used cautiously and more data should be collected to confirm the model results.

4.2.1.7 RDII PREDICTION COMPONENTS OF MODELING SOFTWARE

Most hydraulic modeling software includes methods for generating RDII based on parameters entered by the user. These may include one or more of the methods described earlier. Note that the software may use different terminology to describe these methods.

4.2.2 GROUNDWATER

Flow model simulations should account for the influence of groundwater and soil moisture on sewer flow. The moisture content is defined by season, storage volume, evaporation rates, and hydraulic conductivity. The model should respond to each wet weather event uniquely, considering long dry periods, seasonal variations in wet weather, and increases in flow from back-to-back rain events, etc.

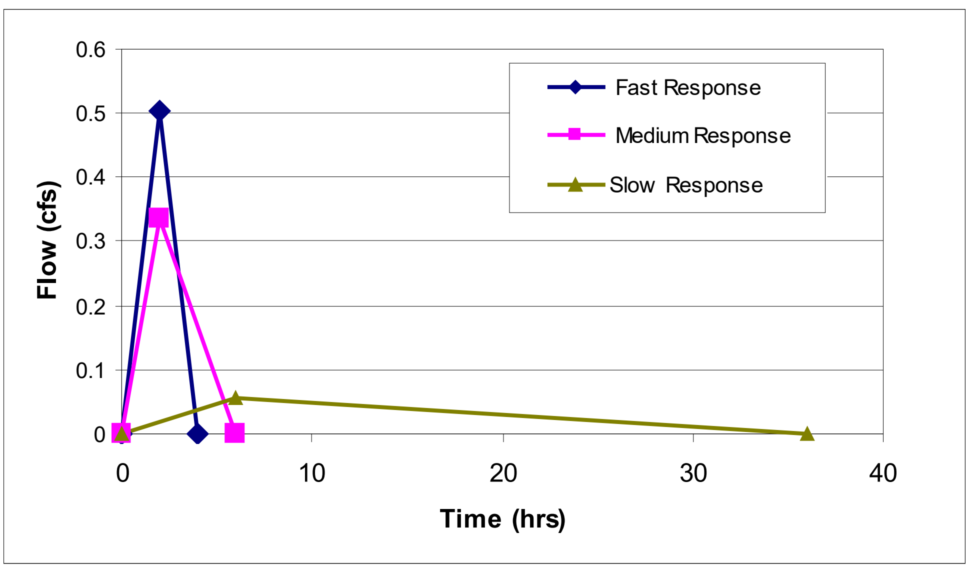
4.2.3 RTK Synthetic Unit Hydrograph

The RTK method incorporates a unit hydrograph to simulate the rainfall derived I/I (RDII) in the sewer system. This method includes three (3) parameters that together define the shape of the unit hydrograph. The "R" represents the fraction of rainfall entering the sewer system as RDII. The "T" represents the time to reach peak flow. The "K" denotes the ratio of the time of recession to the time to peak flow ("T"). Each triangular unit hydrograph has its own R, T, and K parameters.

Each meter basin has three (3) RTK unit hydrographs (Denoted RTK_1, RTK_2, RTK_3). A high R value with low T and K values indicates a fast, inflow driven RDII response. A low R value with high T and K values designates infiltration driven RDII. In this hydrologic model, the inflow-driven RDII response should be defined by RTK_1 whereas the infiltration-driven RDII is defined by RTK_2 and RTK_3.

The RTK unit hydrographs may be modified by an initial abstraction. The initial abstraction absorbs the first part of a rain event. After that depth of rain is satisfied, the subsequent rain contributes to RDII and appears in the simulated flow hydrograph.

Figure 4-3. Synthetic Unit Hydrographs



4.3 HYDROLOGIC MODEL DEVELOPMENT

The steps in the model development process are:

- Data collection
- Model building
- Calibration
- Model use
- Documentation

Guidelines and requirements for each of these activities are included in this section. Although documentation is depicted as the last step in this process, good record-keeping practices should be followed throughout the model development to facilitate documentation. The data describing the collection system geometry will form the attributes and boundaries of the model. These data may be entered directly from GIS or from other database formats. Regardless of the data source, care shall be taken to ensure that the network connectivity and attributes are correctly represented in the model.

4.3.1 HYDROLOGIC MODEL DEVELOPMENT PROCESS

Development of the Hydrologic Models shall be will be performed by ReWa in consultation with the Collection System Users. ReWa shall maintain the Hydrologic Model.

4.3.2 GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

Readily available GIS data shall be used to support the data capture effort during the model building process. Information of this type may include:

- Topographic mapping/digital terrain model
- Stream and hydrologic mapping
- Flood maps
- Sewer system maps (service areas, connectivity, accounts/billing information)
- Parcel information
- Land use information

This information is available from multiple sources including ReWa sewer system mapping, FEMA flood maps, and topographic maps.

4.3.3 RAINFALL RECORDS

Rainfall data shall be used to estimate rainfall derived inflow and infiltration (RDII). Rain gauge data are available from both the U.S. Geographical Survey, ReWa's rain gauge network, existing rain gauge networks in the Collection System User Sanitary Sewer System and efforts undertaken during the flow-monitoring phase. Hydrologic modeling generally requires rainfall data having a resolution of 1-hour or less. All data shall be reviewed for quality issues such as periods of missing or defective rain gauge data before being used in hydrologic modeling.

Rainfall data are required to coincide spatially and temporally with the sewer flow data used to develop the model.

4.3.4 Sewer Flow Monitoring Records

Flow monitoring provides sewer flow data under known conditions. This information is used during model calibration.

Flow monitoring data may be available from:

- Permanent Flow Meters
- Temporary Flow Meters
- Sanitary Sewer Evaluation Surveys (SSES)
- Post-Rehabilitation studies
- Wastewater treatment plant records
- Pumping station records including flow, discharge pressure and wet well elevation

Flow monitoring data shall meet the requirements presented in Section 3. The following locations shall be considered in the development of the flow monitoring plan:

- Sanitary sewer system outlet points
- Mid-points of large or complex sewer basins
- Branch sewers near the junction with a larger sewer where flow from the branch sewer is of concern
- Major sewers near the confluence of branch sewers
- Areas experiencing performance problems where modeling accuracy of such areas is important
- Specific points of concern such as siphons or weirs, where modeling accuracy of such points is important
- Points where ownership of sewer lines changes between ReWa and Collection System User

4.3.5 Operational Information

Operational records provide important qualitative and quantitative data about the performance of a sewer system. This data shall be considered for use during calibration to fine tune the model. The primary sources for this data are interviews with operation staff, SSO databases and maintenance logs. This data may also include records of pumping station discharge pressures. Operational criteria to consider include changes in system operation such as pump replacement, weir adjustments, surcharge, SSO volume, and frequency.

4.3.6 MODEL DEVELOPMENT DOCUMENTATION

This section of the model documentation shall document work from project inception through calibration, including:

- Project definition and purpose
- Data description, sources, reliability, and location of data storage
- Assumptions and simplifications
- Naming conventions for manholes, pipes, structures, etc.
- Flow estimation methodology
- Calibration records including initial variable assumptions and justifications for variable adjustments outside of accepted ranges

The record of data shall be as specific as possible, referencing firm or agency of origin, date, format, modifications, and any commentary regarding data quality or assumptions about the data.

4.4 HYDROLOGIC FLOW MODEL CALIBRATION

Calibration refers to the process of checking the predicted (modeled) flow against actual observed flow, given the rainfall conditions observed for the same period. This process includes double-checking initial input variables for reasonableness and adjustment of input variables. This process shall be followed by verification using a different set of data than was used for calibration.

DWF and RDII shall be treated as separate components during calibration. DWF shall be calibrated adequately before making adjustments to RDII. If baseflows were over predicted to match the total sewer flow, then the RDII would consequently be under predicted. This could produce gross inaccuracies in predicted flow, particularly in evaluation of future conditions when baseflows are extrapolated to account for population growth.

Adjustment of model variables can be guided by both graphical and statistical methods. During the initial iterations, it is convenient to use a graphical comparison of modeled and observed flow, as shown on Figure 4-5.

4.4.1 EXISTING SYSTEM CALIBRATION

The hydrologic model should use multiple storm events captured in flow meter records for calibration, including both wet weather events and dry weather flows. This allows for a robust model able to simulate a variety of events and hydrologic conditions.

4.5 DATA ANALYSIS

The first step in determining the I/I reduction potential is to quantify the base sewage flow, the DWI and the RDII. This is done by compiling and reviewing of historical water consumption records and then comparing the results to the actual wastewater flow meter data collected as described previously. The following sections describe processes for determining each component of the total wastewater flow.

4.5.1 DRY WEATHER FLOW (DWF)

Water consumption data may be used for the base sewage flow determination by assuming 100 percent of the metered water consumption is returned to the sanitary sewer system as sewage flow. Where a Collection System User has more accurate information to support application of a percentage return value to the water consumption data to estimate base sewerage flow, the data shall be used in the base sewage flow estimation. This may include application of flow return values to account for specific usages, such as irrigation, where specific usage was known to occur during the flow-monitoring period.

4.5.2 DRY WEATHER AVERAGE DAILY FLOW (ADF)

The flow at each flow-monitoring site shall be used as the basis for determining the dry weather average daily flow (ADF) for the metered areas and for estimating the dry weather infiltration entering the sewers. In determining the ADF, days with rainfall (and the following 3 days) are normally to be excluded from the analysis. Dry day flows shall be recorded at each monitoring site and averaged to determine the shape of the average diurnal curve for each metered area. A comparison of average daily flows is suggested to identify anomalies in flow patterns. The diurnal curve for each metered area represents the dry weather ADF and shall be used as input to the hydraulic analyses.

4.5.3 DRY WEATHER INFILTRATION (DWI)

Dry weather infiltration for each metered area shall be estimated by subtracting the base sewage flow from the ADF. Engineering judgment shall be applied in the estimation of DWI.

4.5.4 RAINFALL DERIVED INFILTRATION/INFLOW (RDII) EVALUATION

Flows occurring during and after rainfall events that are higher than the dry weather diurnal curve represent potential RDII. The extraneous flow quantity is estimated by subtracting the measured average daily flow diurnal pattern from the wet weather hydrograph. After considering temporal and usage variations, the accumulated extraneous wet weather flow volume can then be estimated. The extraneous wet weather flow quantity (in gallons) for each monitoring site can be divided by the total rainfall accumulation (in gallons) over the metered area to calculate an RDII factor, expressed as a percentage of the total accumulated rainfall that entered the sanitary sewer system.

This evaluation shall be carried out to characterize the volumetric contribution of rainfall to the system for each significant rainfall event captured by flow metering.

The rainfall-derived infiltration can be graphically observed in the receding portion of the wet weather hydrograph. After the rainfall event has passed and the peak flow response has passed, the slower decline of flow back to normal dry weather conditions may be an indicator of the wet weather infiltration. Volumetric quantification of this flow in the system can help determine the volume of I/I entering the system.

For each meter site, a calibrated hydrologic model shall be developed. At least three (3) rainfall events that produced a significant wet weather response shall be used for calibration. The model shall be calibrated for flow.

The calibrated hydrologic model shall be used to prepare a Long-Term Simulation using the rainfall record from the Greenville Spartanburg Regional Airport. Data from the LTS will be statistically analyzed to determine the peak flow recurrence curve using a Log Pearson III (LP3) distribution. The 5-year peak hour flow (PHF) shall be estimated for each meter.

This 5-year PHF will be used to estimate the leakiness of the area tributary to the meter in gallons per acre-day (GPAD). This estimated value will be compared to the leakiness value for the corresponding ReWa Meter Basin, as established by ReWa. If the estimated leakiness from the meter is less than the WRRF service area threshold leakiness, then the area tributary to the meter may be removed from the Target I/I Reduction Area. If the estimated leakiness from the meter is greater than or equal to the ReWa WRRF Service Area threshold leakiness, then the area shall remain in the Target I/I Reduction Area.

4.6 SEWER FLOW EVALUATION

The primary objectives of the flow evaluation are to characterize sewer flow under a range of hydrologic conditions and quantify peak flow for the purposes of identifying Target I/I Reduction Areas. The sewer flow evaluation shall include quantification of base sewage flow, dry weather infiltration (DWI) and rainfall-derived inflow/infiltration (RDII) using the following procedure:

- Separate periods of dry and wet-weather flow with respect to rainfall data
- Establish a typical 24-hour, dry-weather sewer hydrograph
- Estimate DWI by determining average flow rate during off peak hours
- Extract RDII by subtracting the dry-weather flow hydrograph from the wet-weather hydrograph for the event or events of interest

4.6.1 LONG-TERM FLOW SIMULATIONS

Long-term flow simulation shall be used to assess recurrence frequencies for peak flows or volumes. Specific recurrence frequencies are established using probabilistic analysis discussed in this section. Long-term flow simulation considers the range of historical antecedent rainfall patterns and provides sufficient data with which to define the recurrence interval of peak flows.

Flow monitoring data may not be available for a sufficient period of record or for the location of interest to perform a probability analysis. Therefore, flow records may be synthetically generated using a calibrated model and a historic rainfall record. Generally, rainfall data is available for a much longer period of record than typically found in sewer flow monitoring.

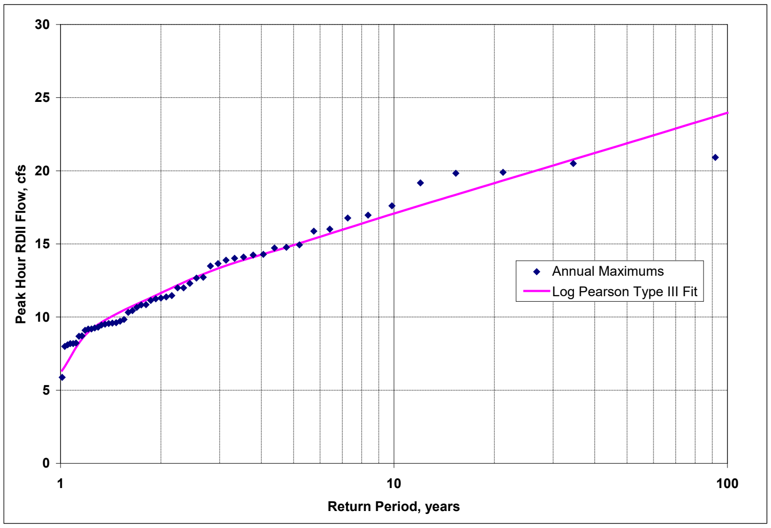
Long–term flow simulation begins with the development of a calibrated model. Once a calibrated model has been developed, a long history of rainfall shall be applied to the model to generate a long-term history of sewer flows. The resulting modeled sewer flows provide an estimation of the actual sewer flows under the same rainfall conditions for the same period of record as the rainfall. Following the long-term simulation, the predicted sewer flow shall be subjected to probabilistic analysis to determine the recurrence interval for various events.

Any representative rainfall record for the area can be used for long-term simulation. To provide regional consistency, long-term historical rainfall data shall be used from the Greenville Spartanburg Regional Airport

For event frequency analyses, the length of the rainfall record required shall be at least twice the frequency of the peak flow recurrence being evaluated. For example, to confidently predict the 5-year peak flow recurrence event would require 10-years of rainfall data.

Probabilistic analysis shall be used to determine event recurrence intervals and can be applied to both peak flow and volume. This method is detailed in most hydrology textbooks. Examples of probabilistic methods include Normal (Gaussian) distribution and Log-Pearson Type III distribution. An example of a peak flow probability graph is shown on Figure 4-4.

Figure 4-4. Example of Probability Plot



The peak flow recurrence frequency is based on long-term sewer flow data for the system (actual or synthesized data) that statistically represents the probability of achieving specific flow values. The peak flow recurrence frequency does not directly correlate to the peak flow resulting from the same rainfall recurrence interval. For example, springtime rainfall events may have higher sewer flow volumes than would result from the same rainfall volume that occurs in summer due to differing soil moisture conditions and groundwater levels. A 2-year peak flow recurrence may occur during a 2-year, 24-hour rainfall event when soils are dry and groundwater is low, while the same sewer flow may be realized during a one-year 24-hour rainfall when the ground is saturated and the groundwater table is high. Resultantly, it is more accurate and defensible to utilize peak flow recurrence than rainfall recurrence as a basis for evaluating sanitary sewer system performance under wet-weather flow conditions.

4.7 POST-REHABILITATION FLOW EVALUATION REPORT

A summary report shall be prepared combining pre-rehabilitation flow meter data, hydrologic flow model information, and post rehabilitation data to evaluate the successfulness of rehabilitation in achieving I/I Reduction Target Value for the areas of interest. This report shall be prepared by ReWa. More information on this report can be found in Section 8.

SECTION 5
CONDITION ASSESSMENT OF SEWER SYSTEM

5.1 OBJECTIVE

Condition assessment of specific sanitary sewer system assets shall be conducted in order to develop a prioritized rehabilitation program that addresses deficiencies which contribute to SSOs or allow I/I into the system and thereby decrease the available existing capacity of the sanitary sewer system. If system assets are to be completely replaced under Section 7, Rehabilitation Planning, condition assessment shall not be necessary or may be deferred. This section provides guidance on development of condition assessment programs to be incorporated into SSES Plans per Section 6 based on the background data review, flow monitoring, and specific problems that are identified.

5.2 DATA NEEDS AND DATA MANAGEMENT

The initial flow monitoring and system data review will give an indication of the field investigations that are necessary to further assess the condition of assets within Target I/I Reduction Areas. Condition assessment requires that certain data be collected to describe the facilities in the Target I/I Reduction Areas and their condition. Various investigation methods can be used to assess the infrastructure components and collect asset information. An example of the types of investigative activities that may be used to assess a range of issues is presented in Table 5-1. The matrix provides general guidance as to appropriate field investigations that may be used to assess the various infrastructure elements.

Data collected during the field investigations will indicate the existing condition of assets within Target I/I Reduction Areas. That information should be compiled in an Information Management System (IMS), such as a computerized maintenance management system (CMMS), if available. The collected information can be managed within the IMS and GIS systems to facilitate rehabilitation planning and execution. At a minimum, the data shall be stored in an open data format that can easily be accessed in an ODBC (Open data base connectivity) compliant format.

	Records Review	CCTV Mainline	CCTV Lateral	Manhole Inspection	Smoke Testing	Dye Testing	Night Flow Isolation	Pressure Monitoring	Flow Monitoring	Ground Water Monitoring	Rainfall Gauging		Pumping Test	Wet Well Inspection		Pump Run Time Assessment
SERVICE LATERALS – PUBLIC SIDE																
Capacity																
Evidence of I/I			●		●	●		●		●						
SSOs			●		●	●		●								
Surcharging			●					●								
Structural Condition																
Material Stability			●													
Age	●															
Maintenance																
Roots	●		●													
Grease	●		●													
MAINLINE SEWERS																
Capacity																
Evidence of I/I	●	●			●	●	●		●	●	●					
SSOs	●	●			●	●	●		●	●	●					
Surcharging	●	●				●			●	●	●					
Min Slopes or Grade Reversal	●	●														
Structural Condition																
Line Failure	●	●			●	●										
Sags		●														
Joint Misalignment		●			●	●										
Defect Rehabilitation	●	●			●	●										
Age	●	●			●											
Maintenance																
Roots		●														
Grease		●														
MANHOLES																
Capacity																
Evidence of I/I						●	●		●	●	●					
SSOs						●	●		●	●	●					
Surcharging						●			●	●	●					
Structural Condition																
Material Stability						●										
Age						●										
Maintenance																
Roots	●			●												
Grease	●			●												
FORCE MAINS																
Capacity																
Excessive System Pressure	●							●		●	●		●			●
Surcharging	●								●	●	●					
SSOs	●								●	●	●					
Structural Condition																
Air Vents	●															
Pipe Failures	●															
PUMP STATIONS																
Capacity																
Excessive Pump Runtimes	●								●	●	●		●			●
Surcharging	●								●	●	●			●		
SSOs	●								●	●	●			●		
Structural Condition																
Material Stability	●													●		
Age	●													●		
Operations																
Air Entrainment	●													●		

5.3 FIELD INVESTIGATION APPROACH

The objective of the field investigation is to provide an appropriate level of system information to support sound rehabilitation and/or replacement decisions and identify I/I sources that require abatement.

Field investigations shall be conducted in a comprehensive or phased approach to identify deficiencies in Target I/I Reduction Areas. A phased approach may be used to progressively evaluate and screen. Table 5-2 depicts an example of how a phased investigation approach may be planned.

Table 5-2 Example of Phased Field Investigation Approach

I Initial Field Reconnaissance & Records Review
- Manhole Checks
- Pump Station, Wet Well, and Force Main Evaluation
- Critical Location Inspection Determination

II Targeted Field Inspection
- Manhole Inspections
- Smoke/Dye Testing
- Limited CCTV/Digital Imaging Inspection Associated with Dye Testing
- Night Flow Isolation

III Comprehensive Field Evaluation
- Comprehensive Main Line CCTV/Digital Imaging Inspection
- Sewer Service Lateral Inspections
- Comprehensive Manhole Inspections

IV Prompt Attention to Identified Severe System Deficiencies
- Prompt Repair Identification and Repair

Various types of investigations can be used to identify where rehabilitation or repair work should be performed and to determine the type and extent of rehabilitation. In Target I/I

Reduction Areas that have known I/I problems or defects that have resulted in SSOs, a comprehensive condition assessment of the gravity sewer system may be initiated without the need for a phased approach. The field investigation techniques described herein may be undertaken as a comprehensive field evaluation or may be focused on a specific field activity where known problems exist. The field reconnaissance program should be based on the background data review, flow monitoring data, pump run time analysis, existing condition assessment and SSES reports, evaluation of SSO history, sewer service call history, and review of engineering and operations information.

5.4 PROCEDURES FOR ASSESSMENT ACTIVITIES

The following procedures for sanitary sewer assessment activities define available and consistent techniques to be used in field investigation. Performing these activities in a consistent manner will aid in the evaluation of data and can provide a regionally common basis for condition assessment.

The following sections provide guidelines for conducting field investigation of sanitary sewer systems. Activities that shall be implemented, where appropriate include:

- Gravity Sewers
- Manhole Inspections
- CCTV Inspections
- Smoke Testing
- Dye Testing
- Night Flow Isolation/Micrometering

5.4.1 GRAVITY SEWERS

Gravity sewers shall be inspected for I/I defects, structural conditions, capacity problems and maintenance issues which may negatively impact performance. Gravity sewer inspections shall include manhole inspections, CCTV inspections, smoke testing, dye testing, and night flow isolation, as appropriate.

5.4.1.1 MANHOLE INSPECTIONS

One of the most useful methods to determine sanitary sewer system condition is to perform and document inspections of manholes. Manholes have the potential to allow significant quantities of I/I into the sanitary sewer system (such as when manhole lids are lower than the surrounding surface and drain storm water when streets are flooded during wet weather). Manhole inspections can also provide indication of surcharged conditions in mainline sewers. Manhole inspections should be conducted to obtain information on manhole conditions and to observe sewer flow conditions, including indications of unacceptable surcharging. Manhole inspections shall be conducted in Target I/I Reduction Areas that potentially have I/I problems. Manhole inspections shall be conducted in accordance with current MACP NASSCO standards as of the Initiation Date.

In conjunction with manhole inspection activities, manholes and cleanouts in areas subject to flooding, ponding, or submerged tidal conditions should be observed and noted. It should be noted if the cleanout is broken or if the manhole cover allows ponded water to enter the manhole.

A NASSCO Level 1 Manhole Inspection should be conducted to determine the general condition of a manhole. The surrounding area should be observed and noted if the manhole is located within an area that is conducive to flooding over the top of the manhole. Manholes found to be surcharged may need to be re-inspected during a lower flow period. If a NASSCO Level 1 manhole observation provides evidence of the manhole being a significant I/I source, a NASSCO Level 2 Manhole Inspection shall be completed to specifically determine what defects exist in the manhole and its connecting pipes, unless the manhole is planned for replacement or complete rehabilitation. This information should be used to determine what corrective measures will be needed to remedy the observed deficiencies.

Each manhole shall be assigned a unique identifier if not previously assigned. The manhole identifier will be used to identify each manhole where an inspection is performed. Information and condition ratings should be collected on the manhole cover, frame, adjustment rings, cone, steps, wall, bench, and channel as well as connecting influent and effluent pipelines.

5.4.1.2 CCTV INSPECTIONS

CCTV inspection should be used to assess the condition of sewer lines by identifying structural problems, points of inflow and infiltration, capacity issues, and system blockages. The data collected should be compatible with and easily integrated by the Utilities' IMS. The CCTV inspection shall be conducted and recorded in accordance with current NASSCO PACP© standards.

5.4.1.3 SMOKE TESTING

Smoke and/or dye testing should be conducted as part of the evaluations in areas that are suspected to have inflow problems. Limited CCTV inspections should be used in conjunction with smoke testing to verify the location of cross connections and inflow sources that are identified.

The entire section being tested should be visually inspected by walking along the route of sewer line watching for smoke leaks. The location of smoke leaks should be marked, noted, numbered, and photographed. The photograph number corresponding to each leak should be noted. Cleanouts and failures that are observed to produce smoke should also be noted if they are in an area subject flooding.

5.4.1.4 DYE TESTING

Dyed water testing may be used to verify connectivity, direction of flow, sources of I/I, as well as illicit connections to the system. Dye testing may be used to complement smoke testing to verify these sources.

Prior to dye testing, the line to be tested should be cleaned. The downstream manhole should be monitored to observe if dyed water passes through the system and the estimated quantity noted. If sufficient dye water passes through the downstream manhole, a CCTV inspection shall be performed to identify the location and magnitude of the source of flow.

5.4.1.5 NIGHT FLOW ISOLATION/MICROMETERING

Nighttime flow isolations may be used to trace sources of infiltration. Night flow isolations may be used to locate and quantify the amount of infiltration entering a sewer system. Night flow isolations are typically performed to narrow down and identify reaches that have excessive infiltration that can be pinpointed for further investigations.

Night flow isolations typically are performed during low flow periods, between the hours of midnight (12AM) and 6 AM. The flow measurement should be conducted with a weir structure that is suitable for the size pipe being isolated. The upstream reaches should be plugged, whenever flow conditions warrant, to provide a quantification of infiltration in each reach of line. When flow conditions do not allow for plugging, differential measurements should be used upstream and downstream for the section of pipe being investigated. Any known sewage flows that contribute flow normally under nighttime conditions in the line under investigation should be noted for the section of line under investigation.

Micrometering may be used to identify/isolate areas with higher I/I. Micrometering may be through special purpose weirs and/or depth measurements using special purpose meters.

5.5 ASSESSMENT STANDARDS FOR GRAVITY SEWER SYSTEMS

5.5.1 NATIONAL ASSOCIATION OF SEWER SERVICE COMPANIES (NASSCO)

To standardize sewer pipe defect coding and ratings in the United States, NASSCO developed industry-accepted standards. NASSCO has also developed rating standards for manhole and lateral defects as well. The following programs have been developed by NASSCO:

- A standard coding system
- A training and certification program
- Standardized data format
- A certification for data collection software vendors
- Mapping symbology standards

- A standard condition rating system

All defect coding and condition assessment shall be based on current NASSCO standards to provide consistency.

5.5.1.1 PIPELINE ASSESSMENT CERTIFICATION PROGRAM (PACP)

The PACP establishes standards for the assessment of sewer mains using information obtained through CCTV inspections. This standard will be used to assess, evaluate, and categorize gravity mains within the sanitary sewer systems.

5.5.1.2 MANHOLE ASSESSMENT CERTIFICATION PROGRAM (MACP)

The MACP uses the established defect coding system found in the PACP and incorporates many of the American Society of Civil Engineers (ASCE) manhole standards as well. The MACP standard will be used to assess, evaluate, and categorize manholes within the sanitary sewer systems.

5.5.1.3 LATERAL ASSESSMENT CERTIFICATION PROGRAM (LACP)

The LACP uses the same defect coding system found in the PACP because of the similarities between main line systems and laterals. This standard may be used to assess, evaluate, and categorize lateral systems within the sanitary sewer systems.

5.6 PROMPT REPAIR GUIDELINES

5.6.1 Conditions to Warrant Prompt Repairs

Certain asset conditions will warrant prompt corrective action when found during SSES work. Defects that pose an imminent risk of failure and warrant prompt repair may include, but are not limited to, partially collapsed pipe, pipe with holes (missing sections), pipe with extensive exposed rebar (concrete), joints that are significantly displaced, and pipe with displaced bricks, where such defects are determined to:

- Pose an immediate threat to the environment
- Pose an imminent threat to the health and safety of the public
- Create operational problems that may result in SSOs
- Contribute substantial inflow to the system

These assets may be operable at the time of discovery but could have potential for severe consequences and a high likelihood of failure.

5.6.2 Removal of Illicit Connections

Illicit connections that contribute substantial inflow to the sanitary sewer system warrant prompt corrective action when discovered. Illicit connections that are identified the sanitary sewer system shall be eliminated. Such connections may include storm drains, roof leaders, sump pumps and area drains that are directly connected to the sanitary sewer.

5.6.3 CONDITION ASSESSMENT DOCUMENTATION

Upon completion of the field investigations, documentation shall be prepared that references the field procedures used and presents the investigation results, alternative analyses, findings, conclusions, and recommendations. These documents will be used to prepare the rehabilitation plan as described in Section 7. The documentation shall include the following minimum content:

- TITLE PAGE
  - Project Title
  - Collection System User Contact Information
  - Basin, Submeter Basin ID
  - Vicinity Map
- TABLE OF CONTENTS
- INTRODUCTION
  - Purpose
  - Scope
  - Background
  - Vicinity Map
- METHODOLOGY AND INVESTIGATIVE APPROACH
- EXISTING FACILITY EVALUATION
  - Inventory of Sanitary Sewer System
  - Pumping Station Inspection
  - Condition Assessment Evaluation
  - Field Investigation Results
    - Manhole Inspections
    - CCTV Inspections
    - Smoke Testing
    - Dye Testing
    - Night Flow Isolations/Micrometering
- FINDINGS, CONCLUSIONS & RECOMMENDATION
- APPENDICES
  - Field Data (Compiled Raw & Analyzed)
  - System overview and detailed maps, for all project types

Note: This format is a general guideline to be used in sewer basin investigations.

SECTION 6
SSES PLANNING

An SSES Plan shall be developed either at the ReWa Meter Basin or Submeter Basin level considering the results of sewer flow monitoring and other relevant information, including the SSO characterization analyses. The plan shall identify Target I/I Reduction Areas; the activities to be performed in those basins; and a schedule for conducting the SSES work.

6.1 SSES PLAN DEVELOPMENT

An SSES Plan shall be developed to meet the following objectives:

- Identify and prioritize areas for investigation
- Establish baseline estimates of I/I
- Select the detailed approach to provide sufficient information for condition assessment activities
- Coordinate improvements to records and mapping that may be needed
- Establish a schedule of activities

The typical approach to detailed investigations is to perform preliminary evaluations as a basis for ascertaining the need for further detailed field investigations. For example, when the case can be clearly identified for replacement of certain reaches of sewer mains based on initial field reconnaissance, supplemental field investigations may not be cost effective or necessary. Conversely, there may be cases where the cost of further detailed investigations can potentially result in project cost savings through better defining the required scope of upgrade work.

Information from the field investigations is used to evaluate sanitary sewer system conditions. Field investigations to be used in the SSES are detailed in Section 5, and generally include:

- Gravity Sewers
  - Manhole Inspections
  - CCTV Inspections
  - Smoke Testing
  - Dye Testing
  - Night Flow Isolation
  - Wet Weather Observations

Target I/I Reduction Areas that exhibit wet weather flows in excess of the WRRF Threshold Leakiness shall be evaluated using smoke testing, manhole inspections and gravity sewer shall be investigated with CCTV.

6.1.1 IDENTIFICATION OF AREAS FOR INSPECTION

Sub areas within Target I/I Reduction Areas shall be selected based on submetering data where the subarea leakiness exceeds the WWRF threshold leakiness. These areas need to be uniquely identifiable to track SSES activities and for ease of reference.

Each basin shall be inventoried to identify the specific facilities that will be investigated and scope of the investigation. Verification of system connectivity will also be necessary to trace sources of I/I. This shall include mapping of:

- Pipelines
- Manholes
- Public Service Laterals (gravity main line to property line)
- Public Clean Outs (if applicable)
- Pump Stations
- Pumps
- Force Mains
- Valves
- Flow Control Structures
- Stream or Aerial Crossing
- Siphons

6.1.2 IMPLEMENTATION SCHEDULE

All work related to the SSES Plan shall be completed prior to the submittal of the Rehabilitation Plan described in Section 7. A detailed schedule for conducting the SSES work shall be established in the SSES Plan. The SSES Plan shall be reviewed and approved by ReWa.

In general, the sequence of activities is as follows:

- Review of Existing Information to Characterize SSOs and Identify Data Gaps
- Flow Monitoring Program Development and Implementation by ReWa
- Development and Submittal of the SSES Plan
- Execution of the SSES Plan
- Prompt Attention to Severe Defects
- Rehabilitation Planning
- Rehabilitation Execution
- Post-Rehabilitation Flow Monitoring/Modeling by ReWa

A specific schedule outlining the activities to be conducted shall be established for inclusion in the SSES Plan. Notification that field activities have been completed shall be submitted to ReWa within one month following completion of the work.

SECTION 7
REHABILITATION PLANNING

7.1 PURPOSE

A Rehabilitation Plan shall be developed to address deficiencies identified in the Target I/I Reduction Areas; including control of I/I sources; and improvements needed to ensure sustainability of the regional sanitary sewer system and protect water quality, human health, and the environment. Each Rehabilitation Plan shall be specific to either a ReWa Meter Basin, a Submeter Basin or a group of Submeter Basins within the same ReWa Meter Basin. Rehabilitation shall be considered the repair or replacement of existing sewer assets to restore or improve the performance of the regional sanitary sewer system.

Factors to be considered in the development of the Rehabilitation Plan include:

- Location, cause, and frequency of SSOs
- Leakiness of the area as measured by the 5-year peak hour flow in gallons per acre-day (GPAD)
- I/I reduction potential
- Structural condition of assets
- Operational and Maintenance (O&M)-related issues of assets
- Criticality of the pump station, sewer basin, or sewer
- Durability and useful life of various remedies

The I/I defects, structural and O&M conditions of the assets shall be identified in Condition Assessment documentation. The durability, useful life, and I/I mitigation effects of rehabilitation measures shall be considered when comparing asset repair versus asset replacement alternatives.

The criticality of individual assets shall be considered during the prioritization of projects in the Rehabilitation Plan. The prioritization shall consider the risk and consequence of failures that may be prevented or mitigated by each project. Projects that mitigate areas of high leakiness or high absolute values of I/I reduction, chronic SSOs and conditions leading to environmental, public health, or safety risks will be given the highest priority.

7.2 GOALS

The goals of the Rehabilitation Plan are to:

- Prevent SSOs by addressing localized significant defects and bottlenecks in the sanitary sewer system
- Reducing I/I and thereby peak flows
- Ensure sustainability of the infrastructure assets by addressing identified deficiencies
- Identify means and methods to remedy the problems

7.3 I/I REDUCTION APPROACH

Best management practices and industry standards should be used to estimate the percent I/I that can be removed within the Target I/I Reduction Area based on observed defects, general pipe/manhole condition, material of construction, and estimated I/I contributions within the sanitary sewer system. Consideration shall be given to the dynamic nature of the I/I sources and the possibility of migration. Comprehensive rehabilitation of the public mains, connections, public laterals from the main to the right of way and manholes shall be the preferred approach. There may be limited areas where discrete inflow sources are the dominant I/I defect and a more targeted approach can be applied in these areas. Understanding the effectiveness of the sewer rehabilitation I/I control program is essential to making the right decisions regarding rehabilitation.

Various rehabilitation and replacement methods have differing levels of effectiveness, maintenance impacts and life spans. These variations should be considered when evaluating the costs and benefits of alternatives.

For each Target I/I Reduction Area, the Collection System User shall assess the cost of using rehabilitation to reach the I/I Reduction Target Value. The Collection System User shall make an affirmative commitment which will be relied upon in ReWa’s Wet Weather Program in terms of post rehabilitation peak flow in all Target I/I Reduction Areas. All costs developed in the Rehabilitation Plan shall be stated in the dollar value in the year the plan is submitted.

7.4 PRIORITIZATION OF PROBLEMS AND IDENTIFIED DEFECTS

The prioritization of significant defects is needed to develop a plan to systematically reduce I/I, and ultimately reduce SSOs, that occur in the system. The prioritization shall focus on the most severe defects and areas with the majority of SSO occurrences. In addition, there are several other factors that need to be considered when working through the prioritization. Items to consider when prioritizing rehabilitation activities include:

- Quantity of I/I entering the system and potential for I/I reduction
- Number and severity of system defects
- Number of SSOs that could be avoided if the system were rehabilitated
- Operation and maintenance history and costs
- Probability and consequence of failure of the sanitary sewer system
- Available capacity
- Estimated cost of the proposed rehabilitation
- Technical complexity of the rehabilitation activities and potential secondary impacts

A ranking system shall be developed that accounts for factors that influence the prioritization of system improvements. Individual utilities may weight the criteria differently and/or may add additional criteria based on their need and desired priorities. In any case, the prioritization shall consider the above criteria as a minimum.

7.5 REHABILITATION ALTERNATIVES EVALUATION

Alternative approaches to rehabilitation shall be considered in the development of the Rehabilitation Plan. This may include rehabilitation and/or replacement. Where rehabilitation is selected a comprehensive approach shall be used that addresses I/I in the Collection System Users Sanitary Sewer System. Where the vast majority of the I/I is coming from inflow sources, a more targeted approach may be used. Key factors in deciding a rehabilitation method for various facilities will include the: structural condition, mechanical condition, capacity requirements, type of material, accessibility, conflicting utilities and other facilities, extent of repair needed, remaining useful life and cost of rehabilitation or replacement.

7.6 REHABILITATION VS. REPLACEMENT

It will be necessary to determine if failing portions of the system can be rehabilitated or if they will require replacement. Factors affecting this decision include:

- Available capacity
- Structural condition
- Remaining useful life
- Estimated rehabilitation effectiveness
- Future needs
- Change in system functionality or operation
- Pipe slope
- Restoration requirements
- Cost

7.7 METHODS OF REHABILITATION

Several technologies are available for consideration in developing the Rehabilitation Plan, and new technologies are routinely emerging in the sanitary sewer industry. The Rehabilitation Plan shall consider the application of commonly used, commercially proven rehabilitation and replacement methods, advantages and limitations of the technique. Grouting shall not be used as the sole means of I/I reduction but can be used in combination with other techniques to temporarily cut off I/I so that other repairs (CIPP, etc.) can be made.

7.8 REHABILITATION PLAN

7.8.1 REHABILITATION PLAN AND SCHEDULE

Rehabilitation Plans shall be developed to define specific measures that will be taken to reduce I/I and SSOs, the cost associated with the proposed rehabilitation, and the planned timeframe for rehabilitation activities. In addition, each Collection System User shall submit their estimated post rehabilitation peak flows to ReWa as part of the Plan.

7.8.2 Report on Work Completed

Progress on rehabilitation projects that are implemented between the Initiation Date and the submittal of the Rehabilitation Plan shall be fully documented to ReWa. Collection System Users shall provide ReWa with quarterly updates of progress during Rehabilitation construction and shall notify ReWa within 30 days of substantial completion of Rehab Work performed under these Standards. Record drawings showing the actual work performed shall be submitted to ReWa within 120 days of substantial completion.

SECTION 8
POST-REHABILITATION EVALUATION OF TARGET I/I REDUCTION AREAS

8.1 PURPOSE

After the successful completion of SSES-guided sanitary sewer rehabilitation, flow monitoring should continue for an additional six (6) months to allow for observation and assessment of rehabilitation success in meeting the Target Value I/I Reduction. This post-rehabilitation flow monitoring will begin at completion of rehabilitation field work. ReWa will perform the post rehabilitation monitoring and modeling and shall share the results with the Collection System User.

8.2 REPORT REQUIREMENTS

Evaluation of the sanitary sewer rehabilitation success in Target I/I Reduction Areas and/or Submeter Basin should be documented in a report including flow monitoring activities performed, flow monitoring data collected, flow analyses conducted, findings, and conclusions as to whether the Target Value I/I Reduction was achieved. Also included should be a thorough description of correlation between rehabilitation efforts, defects remedied, and corresponding I/I reduction based on post-rehabilitation flow monitoring. The Flow Evaluation Report shall be prepared by ReWa not later than 18 months following receipt of notification that the rehabilitation construction is complete.

The evaluation report shall include the following information:

- TITLE PAGE
    - Project Title
    - Collection System User Contact Information
    - Basin, Sub Basin ID
- EXECUTIVE SUMMARY
- INTRODUCTION
- FLOW AND RAINFALL MONITORING METHODOLOGY & APPROACH
    - Use of Existing Data
    - Monitoring Site Selection
    - Monitoring Equipment Used
    - Data Collection Activities
    - QA/QC Procedures
- MONITORED FLOW CHARACTERIZATION AND ASSESSMENT
    - Data Analysis Overview
    - Dry Weather Flow Analysis
    - Dry Weather Infiltration Analysis
    - RDII and Rainfall Analysis

  - Hydrologic Model Calibration
  - Long-Term Simulation (LTS) Model
- FINDINGS AND CONCLUSIONS
  - Discussions of Findings
  - Comparison of Observed I/I Density to ReWa Meter Basin I/I Density
  - Areas Meeting the Target I/I Reduction Area Criteria
  - Success of Rehabilitation Efforts in achieving Target I/I Reduction Area and/or Submeter Basin Goals
- APPENDICES
  - Field Data
  - System Monitoring Location Maps

In the event the Collection System User fails to achieve the required I/I Reduction Target, a Remedial Rehabilitation Plan shall be prepared and submitted to ReWa for review within one-hundred and fifty (150) days of the notification by ReWa that the Target was not achieved. ReWa will assess the effectiveness of the proposed Remedial Rehabilitation Plan and either recommend changes or approve the Remedial Plan within ninety (90) days of receipt of the Remedial Rehabilitation Plan. The Collection System User shall implement the approved Remedial Rehabilitation Plan within twenty (20) months of ReWa's approval. Reporting and documentation shall be the same as in Section 7.6.2.

SECTION 9
REFERENCES

WEF’s MOP FD-6 “*Existing Sewer Evaluation and Rehabilitation*

NASSCO

South Carolina Department of Environmental Control (SCDHEC) R.61-67, Standards for Wastewater Facility Construction